THREE-DIMENSIONAL GEOLOGICAL MAPPING AND MODELING ACTIVITIES IN THE USGS — OPPORTUNITIES, CHALLENGES, AND CONSIDERATIONS FOR THE FUTURE

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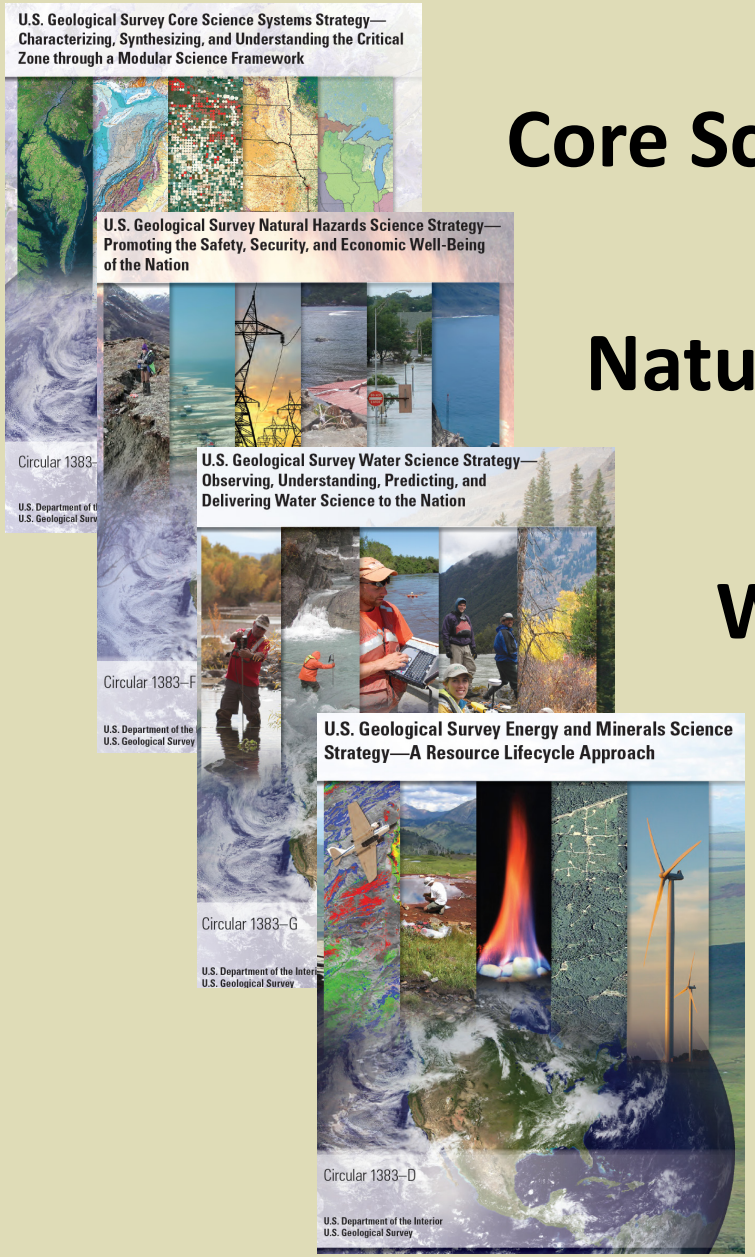
USGS Mission Areas



Core Science Systems (includes NCGMP)

Natural Hazards

Water

Energy and Minerals

U.S. Geological Survey. 2007. Facing Tomorrow's Challenges—U.S. Geological Survey Science in the Decade 2007–2017: U.S. Geological Survey Circular 1309, 69 p.

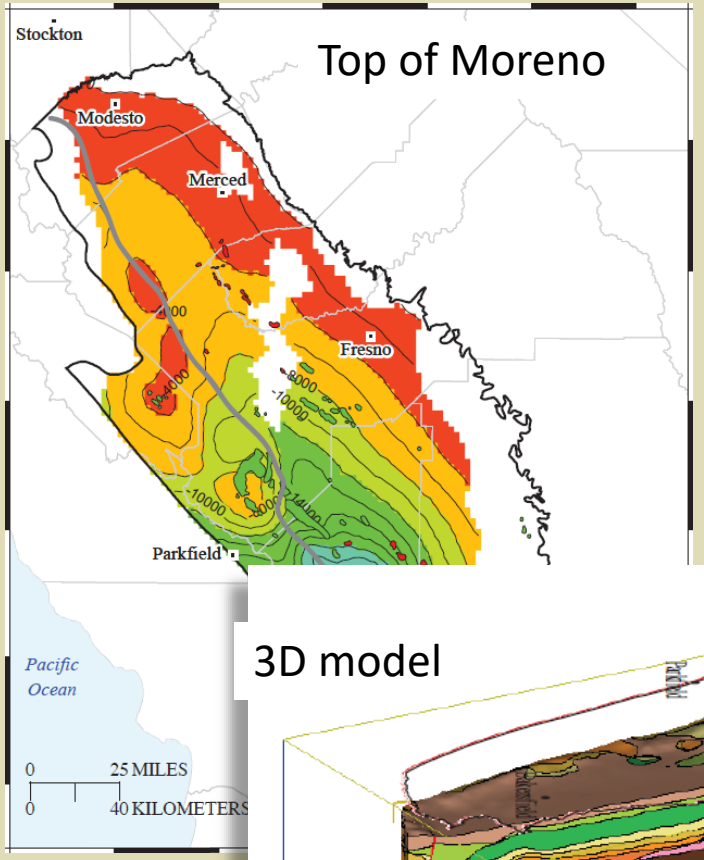
USGS Circular 1383-A through G (2013)

Where is 3D geologic mapping within the USGS?

Three-dimensional (3-D) modelling typically supports research and project work within a specific Mission Area

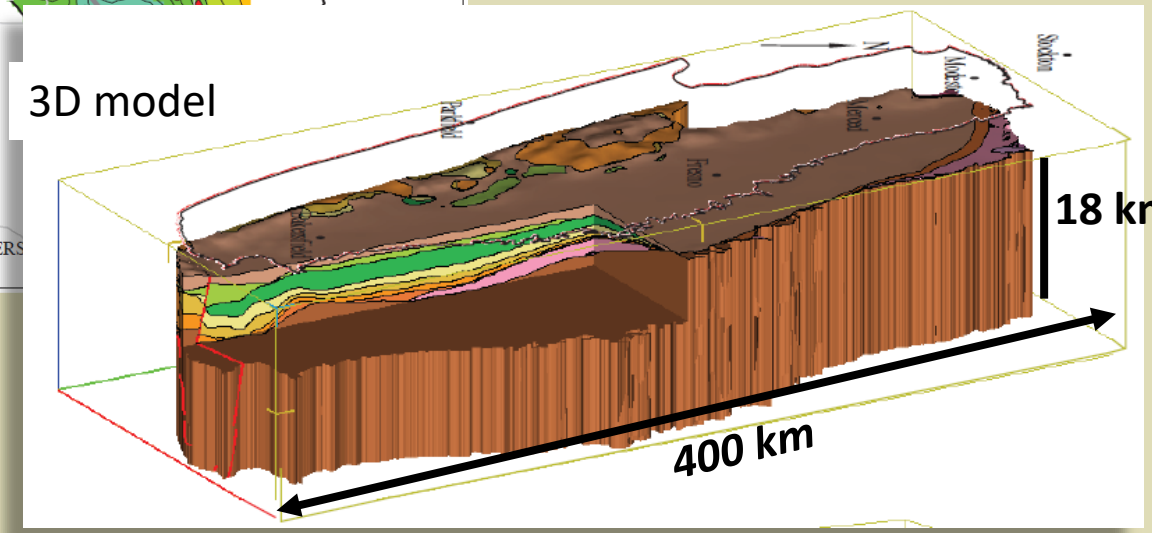
- Decentralized -- spread across USGS Mission Areas
- Modeling occurs at the project level, on a project-by-project basis
- Decisions on type of model, level of detail are made at the project level, on a project-by-project basis
- 50 to 100 people within the USGS routinely or occasionally conduct geological 3-D modelling
- Broad overall mission of the USGS and focused nature of Mission Areas within the organization lead to decentralized 3-D modeling activities
- Variety of 3D approaches and software platforms

USGS Energy and Minerals Mission Area



3-D data management, modeling, and visualization tools applied as part of resource assessments

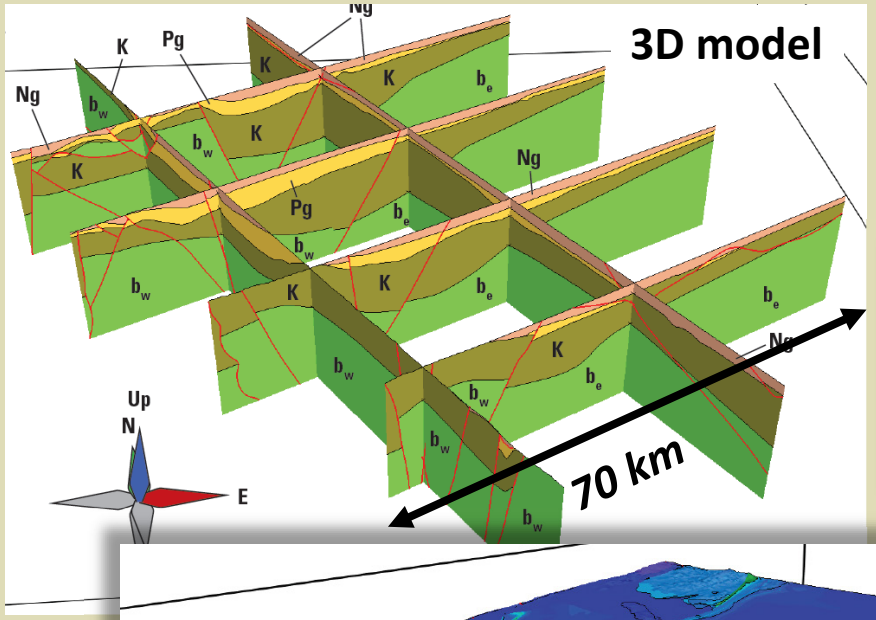
120 km x 400 km
48,000 km²
1/5 UK model
300 7.5' quads



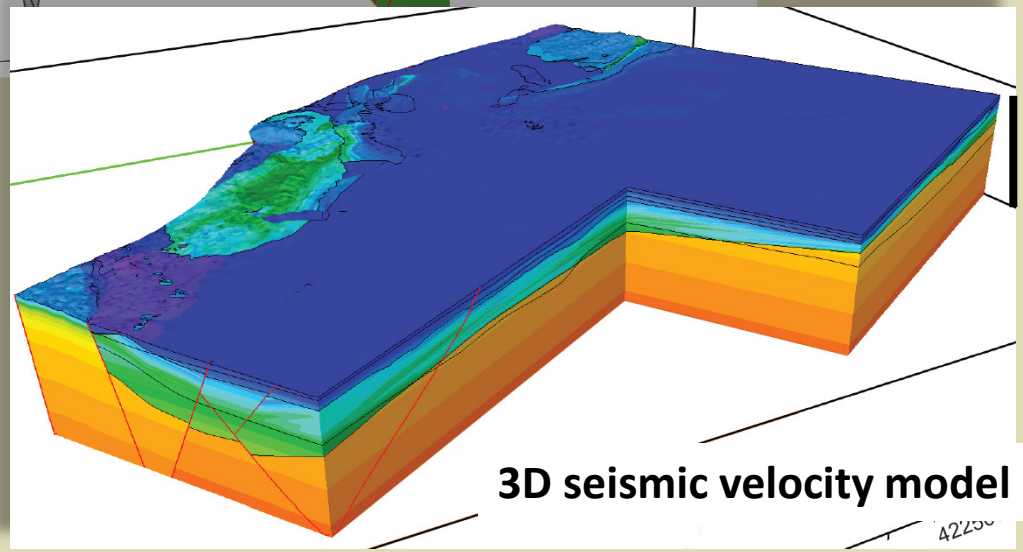
- **Reservoir and play analysis**
- **Geologic input to 4D process models (time-temperature analysis of generation and migration) and 1D, 2D, 3D**
- **Volume calculations**
- **Release of grid files, 3D model with viewer**

San Joaquin basin, CA
Allegra Hosford Scheirer, 2007, USGS Professional Paper 1713

USGS Hazards Mission Area



70 km x 100 km
7,000 km²
3% UK model
44 7.5' quads

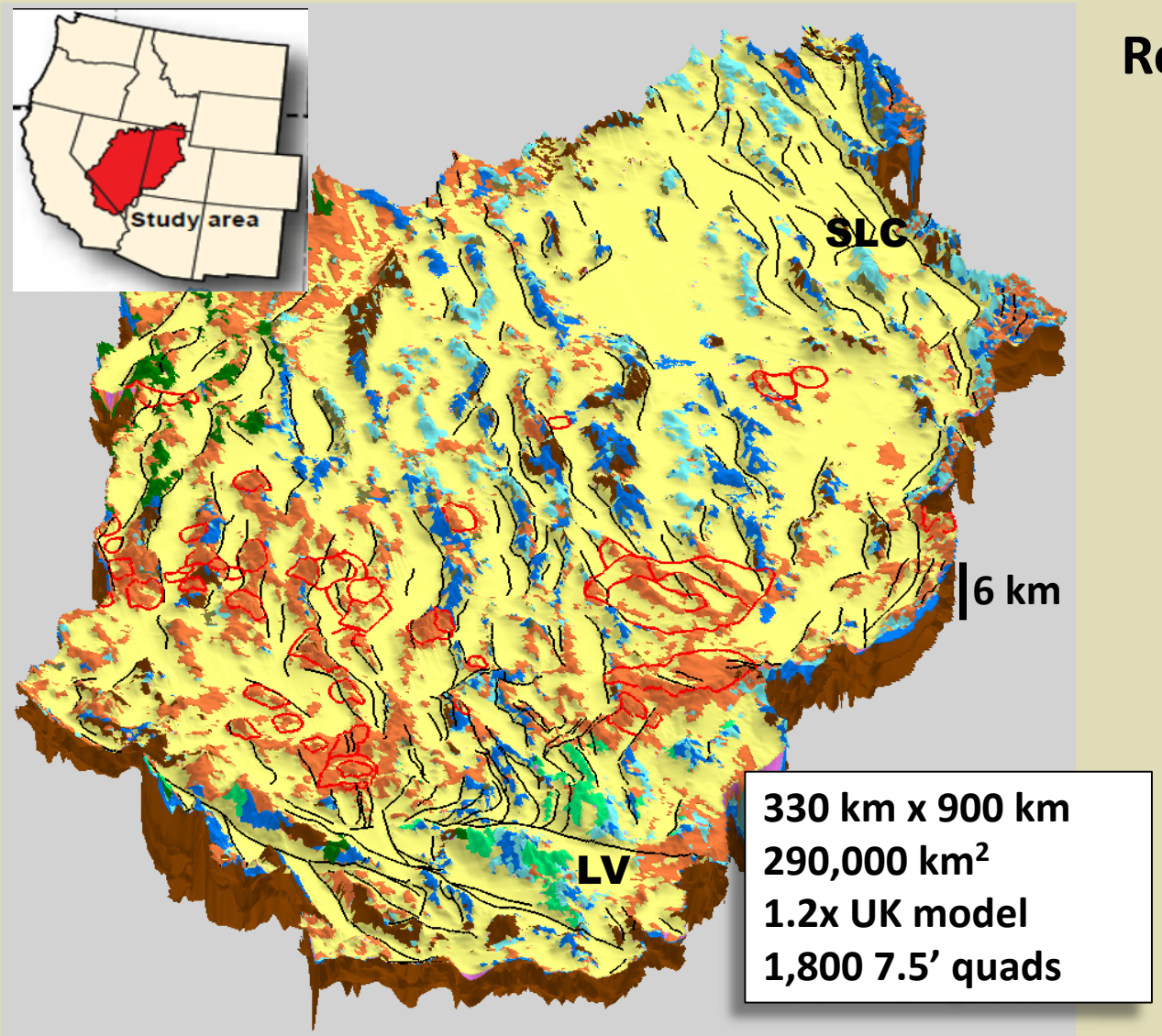


Sacramento Bay Delta, CA
Graymer and others, in review

3-D geologic and seismic velocity variations for earthquake hazard assessment

- Multiple spatial scales
- Crustal scale 3D fault surfaces
- Geology-based 3D seismic velocity models
- Release of grid files, 3D model with viewer

USGS Water Mission Area – Regional-Scale Models

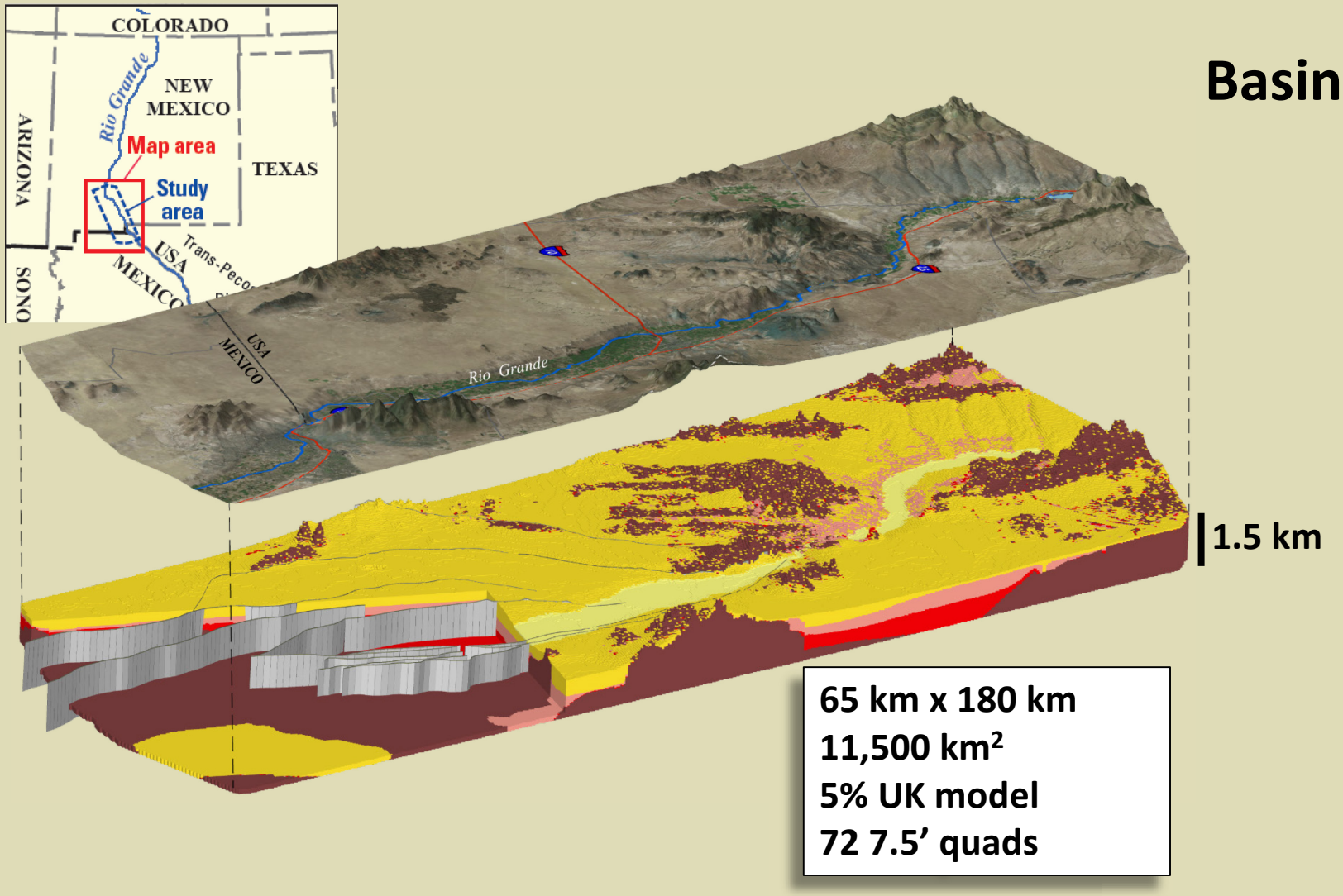


Great Basin Carbonate-Alluvial Aquifer System
U.S. Geological Survey SIR 2010-5193

Regional groundwater availability studies of the Nation's principal aquifer systems

- **Conceptualization of hydrogeologic system**
- **Geologic input to 3D process models (numerical groundwater simulation)**
- **As large as some National models**
- **Release of GIS files**

USGS Water Mission Area – Basin-Scale Models

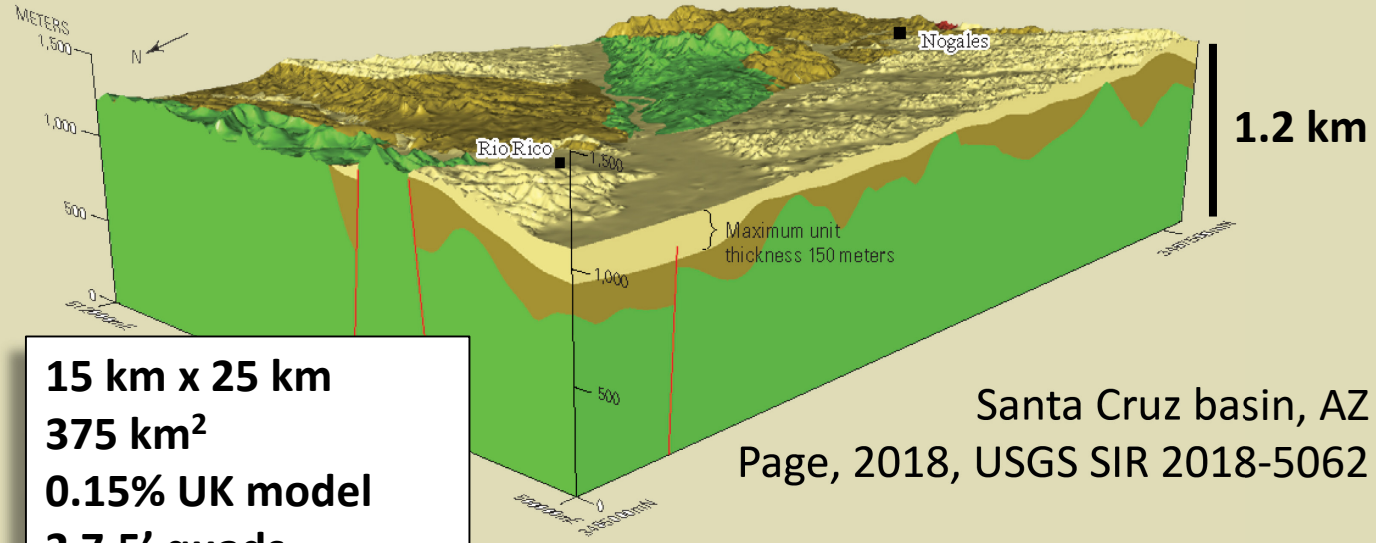


Basin-scale water assessments

- Thickness and extent of aquifers
- Basin depth and geometry
- Lithologic models as a proxy for physical and hydraulic properties
- Release of GIS files

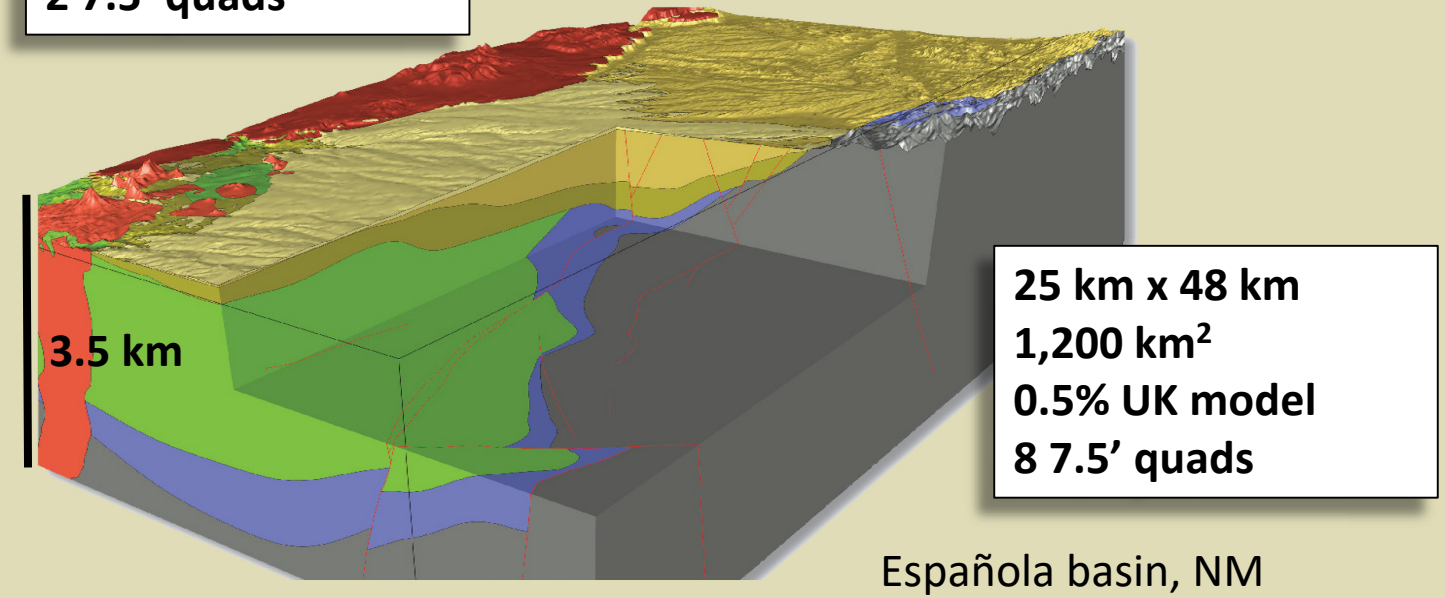
Rio Grande Transboundary aquifer, NM-TX-Mexico
Sweetkind, 2017, USGS SIR 2017-5060

USGS Core Science Systems Mission Area – NCGMP



15 km x 25 km
375 km^2
0.15% UK model
2 7.5' quads

Santa Cruz basin, AZ
Page, 2018, USGS SIR 2018-5062



25 km x 48 km
1,200 km^2
0.5% UK model
8 7.5' quads

Española basin, NM
Pantea, 2011, USGS SIR 2011-5025

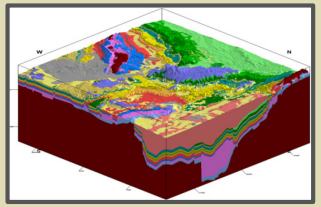
3D geologic models

- **Often tied to objectives of another USGS Mission Area**
- **Sometimes a stand-alone model, not always tied to 2D map**
- **Constructed as opportunity arises**
- **Release of grid files, 3D model with viewer**

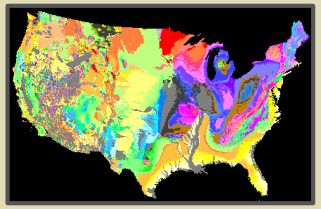
Towards a National 3D Geologic Model

NCGMP STRATEGIC PLAN, 2018–2030

"RENEWING THE NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM AS THE NATION'S AUTHORITATIVE SOURCE FOR MODERN FOUNDATIONAL GEOLOGIC KNOWLEDGE"



"Optimize the use of field and remote sensing and geophysical technologies, and **construct the geospatial infrastructure** required to house a variable-scale national integrated 2D/3D geologic model"



"Populate the geospatial infrastructure … to **create a variable-scale national integrated 2D / 3D geologic framework model** that enables the seamless construction of geologic maps within user-defined regions-of-interest across all of U.S. **by the year 2030**"

USGS 3D Geologic Mapping -- Challenges

- Expertise develops on a project-by-project basis, but there may not be enough knowledge transfer between projects
- Individual researchers and teams acquire 3-D technologies with little to no knowledge or bureau-level coordination of other similar efforts
- Few internal forums for sharing ideas, data, products, and knowledge of emerging technologies
- Published/archived in a variety of formats and outlets

Opportunities for the future

Status Maps – we don't know what we have

- One map or many maps?
- Model footprints
- Single archive for models – data rescue
- Common format and data structure
- Platform to explore and serve the data

National-scale efforts to catalog and maintain already-developed 3-D framework models, beyond the release of models in publications